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U. S. Nuclear Regulatory Commission
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Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Subject: Response to Request for Additional Information for Technical Specifications Change to Revise Steam Generator Inspection Frequency for the Fall 2001 Refueling Outage for Braidwood Station, Unit 1

References: (1) Letter from R. M. Krich (Exelon Generation Company, LLC) to US NRC, "Request for Technical Specifications Change Braidwood Station, Unit 1, Steam Generator Inspection Frequency Revision for the Fall 2001 Refueling Outage," dated February 9, 2001

(2) Letter from M. Chawla (US NRC) to O. D. Kingsley (Exelon Generation Company, LLC), "Request for Technical Specifications Change - Braidwood Station, Unit 1, Steam Generator Inspection Frequency Revision for the Fall 2001 Refueling," dated May 4, 2001

In the Reference 1 letter, in accordance with 10 CFR 50.90, "Application for amendment of license or construction permit," Exelon Generation Company (EGC), LLC requested a change to the Technical Specifications (TS) of Facility Operating License Nos. NPF-72 and NPF-77 for the Braidwood Station, Units 1 and 2. The proposed one-time change revises the Steam Generator (SG) inspection frequency requirements in TS 5.5.9.d.2, "Steam Generator (SG) Tube Surveillance Program, Inspection Frequencies," for the Braidwood Station, Unit 1, fall 2001 refueling outage, to allow a 40 month inspection interval after one SG inspection, rather than after two consecutive inspections resulting in C-1 classification.

The NRC subsequently issued a Request for Additional Information (RAI) letter in Reference 2. The RAI letter requested that additional information be provided within 30 days after receipt of the letter (i.e., by June 4, 2001). The requested additional information is provided in the Attachment to this letter.

A001

Should you have any questions concerning this letter, please contact Ms. Kelly M. Root at (630) 663-7292.

Respectfully,

R. M. Krich
Director - Licensing
Mid-West Regional Operating Group

Attachment: Response to Request for Additional Information for Technical Specifications Change to Revise Steam Generator Inspection Frequency for the Fall 2001 Refueling Outage for Braidwood Station, Unit 1

cc: Regional Administrator - NRC Region III
NRC Senior Resident Inspector - Braidwood Station
Office of Nuclear Facility Safety - Illinois Department of Nuclear Safety

Attachment

Response to Request for Additional Information for Technical Specifications Change to Revise Steam Generator Inspection Frequency for the Fall 2001 Refueling Outage for Braidwood Station, Unit 1

QUESTION 1

"The licensee has stated that it will be following the EPRI PWR Steam Generator Examination Guidelines for their in-service inspections of the replacement steam generators. If there are any exceptions taken to the EPRI Guidelines, please explain them and provide a summary of the basis."

RESPONSE TO QUESTION 1

Two exceptions were taken to the Electric Power Research Institute (EPRI) Pressurized Water Reactor (PWR) Steam Generator (SG) Examination Guidelines during the Braidwood Station, Unit 1 spring 2000 refueling outage. The exceptions along with the technical basis are described below.

1. Top-of-Tubesheet and U-bend Inspection

EPRI PWR SG Examination Guidelines, Revision 5, requires 100% of the tubing be inspected with a qualified inspection technique over a rolling 60 effective full power months (EFPMs). For inspection of the top-of-tubesheet (TTS) roll transition zone and low row (i.e., tight radius) U-bends, the standard bobbin coil inspection technique is not qualified to detect cracking. Because of the extremely low susceptibility to stress corrosion cracking (SSC) of thermally treated Inconel-690 tubes in the Unit 1 SGs, combined with SG design improvements described below, inspection using bobbin coil eddy current is adequate. A technical justification was developed by Exelon Generation Company (EGC), LLC to justify only performing bobbin eddy current inspection of these areas during the first 60 EFPMs of replacement SG (RSG) operation. Use of the technical justification requires review of current industry data prior to each outage in which it will be applied. This assures new degradation has not developed within the industry and that the assumptions in the technical justification remain valid.

One of the main technical justifications for not performing inspections of TTS and low row U-bend regions of the Braidwood Station, Unit 1 RSGs is the performance of the Byron Station and the Braidwood Station, Unit 2 Westinghouse Model D-5 SGs. The Unit 2 SGs contain thermally treated Inconel-600 tubing and operate under essentially the same conditions as the Unit 1 SGs. By demonstrating that the Unit 2 SGs have operated over 60 EFPMs without developing intergranular attack (IGA) or SCC and with the design improvements discussed below, reasonable assurance is provided that the Braidwood Station, Unit 1 SGs will not develop IGA or SSC over this timeframe.

- Improved Tube Material

  A detailed discussion of the benefits of thermally treated Inconel-690 is provided in the Reference letter, Attachment A, "Braidwood Station, Unit 1, Description and Safety Analysis of the Proposed Changes," Section F, "Safety Analysis of the

Proposed Changes." These design improvements help assure that both primary and secondary side IGA, SCC, pitting, and general corrosion will not develop within a time frame greatly exceeding 60 EFPMs of RSG operation.

- Improved Recirculation Ratio

  A detailed discussion of the benefits of increased recirculation flow is provided in the Reference letter, Attachment A, Section F, which concludes that by maximizing the recirculation ratio, secondary side concerns regarding deposit loading, corrosion product transfer, tube dry out, and sludge management are minimized.

- Top-of-Tubesheet Region

  A detailed discussion of the benefits of full depth hydraulically expanded tubesheets is provided in the Reference letter, Attachment A, Section F. The primary benefit is the reduced stress in the hydraulic expansion reducing the residual stress required to initiate SCC. Additionally, both the Byron Station, Unit 2 and the Braidwood Station, Unit 2 contain hydraulically expanded thermally treated Inconel-600 tubes, which have operated greater than 118 EFPMs without detecting SSC or IGA in the TTS region. Plus Point eddy current inspections of 100% of both the Byron Station and the Braidwood Station, Unit 2 SGs were performed and three SG tubes were removed from Byron Station, Unit 2. The tube pull results indicated that there was no IGA or SCC at the TTS location of the three tubes analyzed. Additionally Plus Point inspection results continue to indicate no signs of IGA or SCC.

- U-bend Region

  A detailed discussion of the benefits of the larger radius U-bend and stress relief process applied to the Braidwood Station, Unit 1 RSGs is provided in the Reference letter, Attachment A, Section F. To summarize, the tightest radius U-bend in the RSGs has a centerline radius of 3.6 inches as opposed to the Byron Station and Braidwood Station, Unit 2 SG design, which has a 2.25 inch centerline radius, thus reducing the residual stresses necessary to initiate SCC.

  During the Braidwood Station, Unit 2 spring 1996 refueling outage, after approximately 70 EFPMs of operation, an indication was reported in a row 1 U-bend tube during the first inservice inspection of this region using the rotating coil techniques. 100% of the row 1 and row 2 U-bend tubes were inspected using the rotating coil techniques, but no other indications were detected. The tube was removed from service by mechanical plugging. Subsequent row 1 and row 2 U-bend tube 100% inspections using the rotating coil techniques on the Byron Station and the Braidwood Station, Unit 2 SGs have not detected any other tubes with similar indications.

- Industry Experience

  The review and summary discussed in the response to Question 2 of the industry experience with thermally treated Inconel-690 tubing demonstrates that the operating time and hot leg temperature for Braidwood Station, Unit 1 are comparable to the other units operating with thermally treated Inconel-690 tubing. Since none of these units have reported any signs of IGA or SCC, it is reasonable to assume that inspection of the TTS and low row U-bend regions at Braidwood Station, Unit 1 are not warranted during the first 60 EFPMs of operation.

2. Dual Automated Eddy Current Data Analysis

As part of the RSG eddy current inspection performed during the Braidwood Station, Unit 1 spring 2000 refueling outage, both primary and secondary SG data were analyzed using automated data analysis. EPRI PWR SG Examination Guidelines, Revision 5, Section 6.3.3.3, "Computer Data Screening and Analysis Systems," allows for the use of automated data analysis for both the primary and secondary SG data provided certain conditions are met. As discussed below, Braidwood Station met all of the EPRI PWR SG Examination Guidelines requirements for use of primary and secondary automated data analysis, with the exception of the requirement that, "at least one team should review all data manually." The requirement to review all data manually was developed to ensure the detection and sizing algorithms are not missing degradation signals. In place of reviewing all eddy current data manually, a 20% review of the strip chart data (i.e. 10% primary and 10% secondary) was performed by experienced qualified data analysts (QDAs) who had completed the Braidwood Station, Unit 1 site specific performance demonstration (SSPD) training and testing. Additionally, all calls made by the automated data analysis systems were manually reviewed by a QDA and calls which were discarded by manual analysis were subject to an independent QDA sampling.

Two independent automated data analysis systems were used. One was developed and implemented by Westinghouse Electric Corporation (i.e., ANSER Auto-Analysis Software Module (ADS)) while the other was developed and implemented by CoreStar (i.e., AutoVISION). This ensured complete independent primary and secondary analysis of the data using two different automated analysis systems.

Summarized below are the actions taken to qualify the automated data analysis systems and the technical justification for deviating from Revision 5 of the EPRI PWR SG Examination Guidelines. Note that the automated data analysis was only used for analysis of bobbin coil eddy current data during the Braidwood Station, Unit 1 spring 2000 refueling outage. All Plus Point data was analyzed manually.

- Potential Degradation Mechanisms

  Based on the degradation assessment performed prior to the Braidwood Station, Unit 1 spring 2000 refueling outage, which took into consideration the industry experience of thermally treated Inconel-690 tubing, the following potential degradation mechanisms were identified for the Braidwood Station, Unit 1 RSGs.

  Fan bar/lattice bar wear
  Foreign object wear
  Tube-to-tube contact
  Dents and dings
  Manufacturing burnish marks

  Bobbin coil eddy current techniques are qualified to detect these damage mechanisms. The Braidwood Station, Unit 1 spring 2000 refueling outage degradation assessment provides the details of the site-specific qualification of the eddy current techniques and the results of the degradation assessment.

- Qualification of Automated Data Analysis Systems

  The initial generic performance capability (i.e., qualification) of the automated data analysis systems was demonstrated and documented in accordance with the EPRI Performance Demonstration Database (PDD) program. This initial qualification performed on the EPRI PDD validates the detection and sizing/characterization algorithms for each damage mechanism found in EPRI PWR SG Examination Guidelines, Revision 5, Appendix G, "Qualification of Nondestructive Examination Personnel for Analysis of NDE Data." Both the Westinghouse Electric Corporation and CoreStar automated data analysis systems successfully completed the bobbin portion of the EPRI PDD Examination. The systems also successfully completed the Braidwood Station, Unit 1 SSPD examination prior to the Braidwood Station, Unit 1 spring 2000 refueling outage, using techniques qualified in accordance with our degradation assessment and EPRI PWR SG Examination Guidelines, Revision 5, Section 6.3.2, "Qualified Data Analyst." This demonstrated that the systems were capable of detecting wear, loose parts, dents, dings, tube-to-tube contact and manufacturing burnish marks which have the potential of being present in the Braidwood Station, Unit 1 SGs.

  The qualification was demonstrated independent of human intervention. Human intervention is defined as an analyst operating the automated analysis system deleting, adding or changing a result. In addition, each analyst that operated an automated data analysis system met the SSPD qualification requirements without the automated analysis system.

  The independent QDA reviewed the analysis logic used to establish the auto-screening processes. In addition to the independent QDA reviewing and documenting the analysis logic, both the EGC eddy current Level III and Westinghouse Electric Corporation Lead Level III personnel concurred with the review and documentation.

- Analysis Quality Checks

  Both automated data analysis systems were used in the interactive mode, in which the software detects and analyzes the signals and the analyst reviews the signals identified by the software and compares them with their own analysis of the signals before the results are accepted or rejected.

  In place of reviewing all eddy current data manually, a 20% review of the strip chart data (i.e. 10% primary and 10% secondary) was performed by experienced QDAs who had completed the Braidwood Station, Unit 1 SSPD training and testing. Additionally, all calls made by the automated data analysis systems were manually reviewed by a QDA and calls which were discarded by manual analysis were subject to an independent QDA sampling. Analysis feedback was implemented to ensure appropriate actions were taken to resolve any missed indications in the automated analysis sort and edit criteria.

Reference

Letter from R. M. Krich (Exelon Generation Company, LLC) to US NRC, "Request for Technical Specifications Change Braidwood Station, Unit 1, Steam Generator Inspection Frequency Revision for the Fall 2001 Refueling Outage," dated February 9, 2001

QUESTION 2

"On page 11 of Attachment A in the submittal, the licensee summarized industry experience of the RSGs with Alloy 690 tubing. Please briefly discuss the relevance of the experience in comparison of operating conditions, such as T_{hot} and water chemistry."

RESPONSE TO QUESTION 2

Data was gathered on 54 units containing thermally treated Inconel-690 tubing. The table below contains a listing of these units along with effective full power years (EFPYs) of operation, hot leg operating temperature, and listing of available secondary water chemistry data.

In a comparison of the Braidwood Station, Unit 1 RSG operating time in EFPYs to other units containing thermally treated Inconel-690 tubing, 38 of the 54 units have more operating time than Braidwood Station, Unit 1. To date, no units have reported any signs of degradation other than that associated with tube wear. This further supports our position that IGA and SCC will not develop early in the life of the SGs containing thermally treated Inconel-690 tubing and that SG inspections are not warranted during the upcoming Braidwood Station, Unit 1 fall 2001 refueling outage (see Figure A).

In a comparison of the Braidwood Station, Unit 1 RSG hot leg operating temperature to other units containing thermally treated Inconel-690 tubing, 34 of the 54 units have a higher hot leg temperature than Braidwood Station, Unit 1. When Braidwood Station, Unit 1 raises hot leg temperature as part of the power uprate effort at the beginning of the next operating cycle, eight of the 54 units will have a higher hot leg operating temperature. Since Braidwood Station, Unit 1 currently operates and will continue to operate within the industry temperature range for RSGs and since other plants operating in this hot leg temperature range have not developed IGA or SCC, reasonable assurance is provided that IGA and SCC will not develop early in the life of the SGs and that SG inspections are not warranted during the upcoming Braidwood Station, Unit 1 fall 2001 refueling outage (see Figure B).

The secondary water chemistry program at the Braidwood Station is similar to that of other units containing thermally treated Inconel-690 tubing. With the exception of six plants for which we could not obtain secondary water chemistry information, all of the other units containing thermally treated Inconel-690 tubing listed in the table below utilize all volatile treatment (AVT) for secondary water chemistry control. The AVT at the Braidwood Station consists of methoxypropylamine (MPA) and hydrazine, which is consistent with the EPRI PWR Secondary Chemistry Guidelines, Revision 5, May 2000. This proprietary document provides guidance for PWR secondary water chemistry control.

TABLE
Industry Experience With Inconel-690 Tube Material

Plant	Manufacturer	Model	Chemistry	EFPYs (years)	Hot Leg Temperature (°F)
Braidwood-1	BWI	RSG	AVT (MPA)	1.29	610
Byron-1	BWI	RSG	AVT (MPA)	2.4	610
Beznau-1	Fram	33/19	AVT	5.1	594
Beznau-2	Fram	33/19	unknown	0	594
Catawba-1	BWI	RSG	AVT (MPA)	3.7	613
Chooz B1	Fram	7319	AVT	1	625
Chooz B2	Fram	7319	AVT	1	625
Civaux-1	Fram	7319	AVT	1	625
Civaux-2	Fram	7319	AVT	1	625
Cook-1	BWI	51R	AVT (ETA)	0	599
Cook-2	West	54F	AVT (ETA)	5.9	606
Dampierre-1	Fram	51B	AVT (Morpholine)	6.5	613
Dampierre-3	Fram	4722	AVT (Morpholine)	1	613
Doel 4	Fram	79/19	unknown	2.52	621
Farley-1	West	Delta-75	AVT	0	607
Genkai-1	MHI	52F	AVT (Ammonia)	4.2	613
Genkai-3	MHI	52FA	AVT (Ammonia)	4.3	617
Genkai-4	MHI	52FA	AVT (Ammonia)	2.4	617
Ginna	BWI	RSG	unknown	4.3	589
Golffech-2	Fram	6819	AVT (Morpholine)	4.4	616
Gravelines-1	Fram	4722	AVT (Ammonia)	5.5	613
Gravelines-2	Fram	4722	AVT (Ammonia)	2	613
Ikata-1	MHI	51	AVT	0.5	605
Ikata-3	MHI	52F	unknown	3.3	613
Indian Point-3	West	44F	AVT (ETA)	5.6	602
Kori-1	West	D60	AVT (ETA)	1.1	607
Krsko	West	72W	AVT	0	617
McGuire-1	BWI	RSG	AVT (MPA)	3.4	614
McGuire-2	BWI	RSG	AVT (MPA)	2.5	614
Mihama-1	West	35F	AVT (ETA)	2.3	603
Mihama-2	MHI	46F	AVT (ETA)	3.2	607
Mihama-3	MHI	54F	AVT	1.8	608
Millstone-2	BWI	RSG	unknown	2.7	601
North Anna-1	West	54F	AVT (ETA)	6.5	613
North Anna-2	West	54F	AVT (ETA)	3.9	613
Ohi-1	MHI	52FA	AVT	2.1	617
Ohi-2	MHI	54FA	AVT	0.8	613
Ohi-3	MHI	52FA	AVT (Ammonia)	6.4	617
Ohi-4	MHI	52FA	AVT	5.2	617
Penly-2	Fram	6819	AVT (Ammonia)	6.5	616
Point Beach-2	West	D47F	AVT (ETA)	2.6	597
Ringhals-2	KWU	RSG	AVT	6.9	610

Ringhals-3	KWU	RSG	AVT	3.1	606
Sizewell B	West	F	AVT	3.3	617
South Texas-1	West	Delta-94	AVT	0	620
St. Laurent Dex Eaux B1	Fram	4722	AVT (Morpholine)	5.5	613
St. Lucie-1	BWI	RSG	AVT (DMA)	3.0	599
Summer	West	Delta-75	AVT (MPA)	5.2	619
Takahama-1	MHI	54F	AVT (ETA)	1.9	613
Takahama-2	MHI	52F	AVT (ETA)	3.3	613
Tihange-1	MHI	51F	unknown	3.6	609
Tihange-3	Fram	79/19	unknown	1.42	623
Tricastin-1	Fram	4722	AVT (Morpholine)	1	613
Tricastin-2	Fram	4722	AVT (Morpholine)	1	613

BWI - Babcock & Wilcox International
Fram - Framatome
West - Westinghouse
MHI - Mitsubishi Heavy Industries
KWU - Kraft Work Union
AVT - All Volatile Treatment
MPA - Methoxypropylamine
ETA - Ethanolamine
DMA - Dimethylamine

FIGURE A

Distribution of Thermally Treated Inconel-690 Plants Operating Life

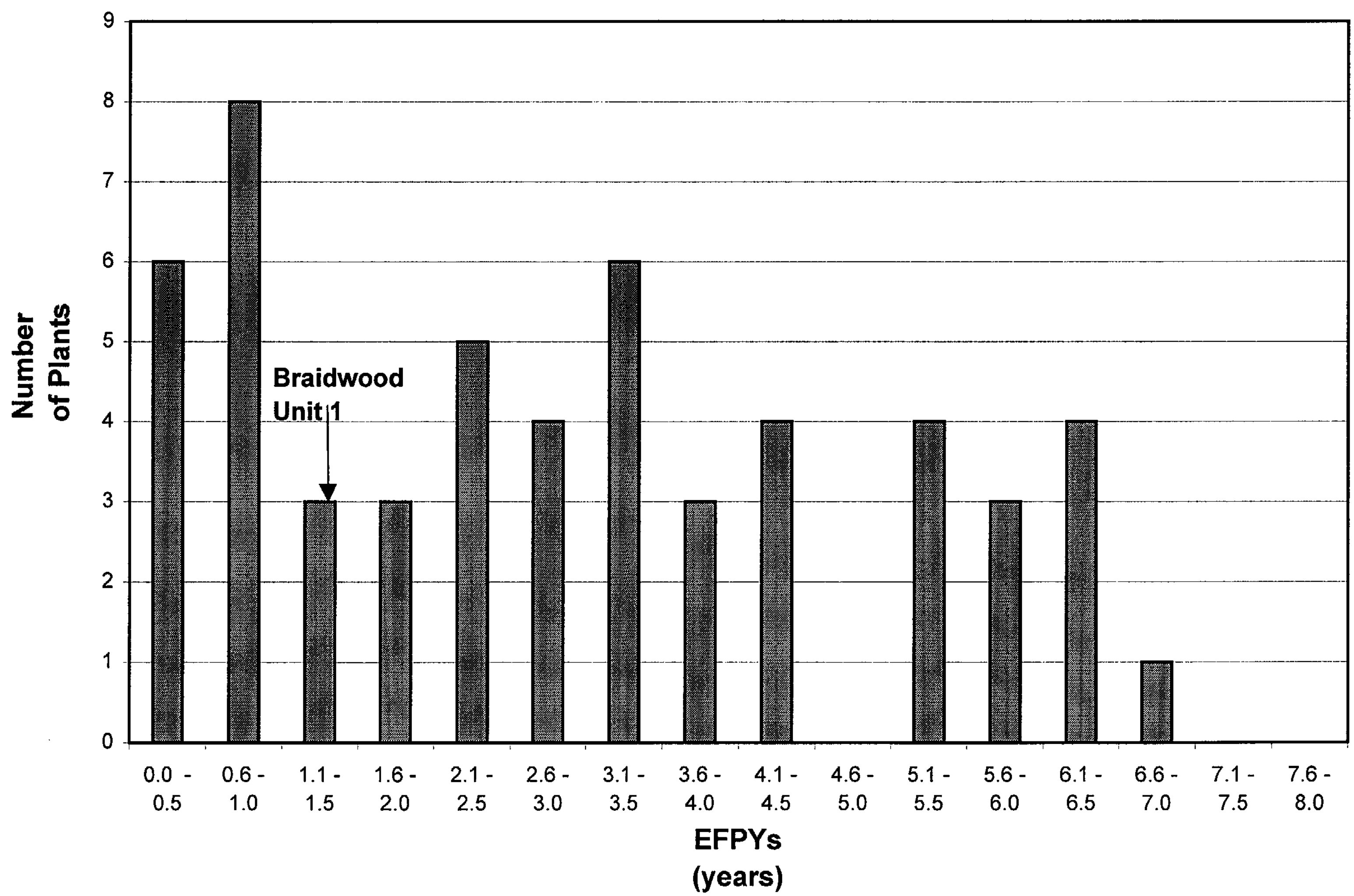

FIGURE B

Distribution of Thermally Treated Inconel-690 Plants Opertaing Temperature